Sercel Land Acquisition Forum

"Improved Land/Reservoir Imaging through High Density and Multi-Component Acquisition"

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Houston, Texas

William F. Lawson, Special Guest Speaker

"R&D: Catalyst for the Next Stage of Seismic Industry Growth"

Thank you very much for the kind introduction and the wonderful hospitality. I am so pleased to be able to address you today.

The NETL is the only fossil energy-focused national lab, with 1,100 employees spread over four sites. Today, I intend to describe some general features of the domestic U.S. oil & gas industry and then discuss some specific DOE projects of potential interest to this group.

We take our oil and gas industry pretty seriously and are proud of the advances we've made over the last century and a half, so let me give you a little perspective that was eye-opening to me.

Twenty-two centuries ago, the Chinese were developing wells for salt brine in Sichuan Province, some as deep as 300 feet. Occasionally, mysterious invisible devils overtook work crews and caused fires and explosions. By 68 A.D., the Chinese learned to ignite the escaping natural gas and used it to heat brine for making salt. Before long, saltworkers were using bamboo pipes to bring both brine and gas to salt factories, where the brine was reduced to salt. Thus we have the first known gas wells, the first local distribution systems, and the first commercial use of natural gas, according to Mark Kurlansky in his book “Salt, A World History.”

The rest of the world spent the 19th and 20th centuries catching up to evolving Chinese science and technology. We have witnessed rapid advances in natural gas and oil technologies over the last few decades. And this forum today documents further advances in technology. But the challenges we face today in **ever-**rapidly depleting reserves, **ever-**increasing demand, an **ever-**aging and vulnerable infrastructure, and an **ever-**sharpened environmental awareness are unprecedented. So it follows that we look to **ever-**more advanced technology for some important solutions to the **ever-**more complex world of natural gas and oil. The price and supply volatilities we see today are symptomatic of these challenges.

The geophysical industry today stands at a crossroads. It has been experiencing a business slump for several years. As it has in the past with the 3-D seismic revolution, it can use new technology—enabled by a new business paradigm—to leverage itself out of that slump.

Research and development, such as that funded by the Department of Energy, can serve as an enabler of the next stage in seismic technology growth.

Before I elaborate on some of that new technology, let's step back a bit to look at the big picture.

Oil and natural gas are the lifeblood of the U.S. economy. Together they account for more about two thirds of the energy consumed in America. Yet all signs point to growing dependence on foreign supplies for both oil and gas. Oil imports today are about 60% of domestic supply and are projected to be 70% by 2025. Even gas is 18% imported today, and that is going to go up. Today there are no economically viable alternatives.

The U.S. pays more for natural gas than nearly any other country. What we will pay in the future is uncertain. EIA projects a moderation in prices to $3.60/Mcf in 2010 and $4.80/Mcf in 2025. AGA disagrees and projects $7.00/Mcf if we make some policy changes and $12.00/Mcf if we don't.

Despite high oil and gas prices, exploration still languishes. New domestic oil and gas targets are in general smaller, technically more difficult, and face greater restrictions, including being off-limits, than ever before. Companies add reserves more by acquisition than by drilling. The end result is fewer reserve additions for the Nation.

It has been estimated that, during the next 20 years, at least 80% of all oil and gas supplies will come from mature fields. Meanwhile, more than two thirds of all the oil discovered in the U.S. remains in the ground. A potential resource of 1,400 TCF of gas also lies underexploited in this country.

But the real U.S. potential is much larger, considering the order of magnitude of unconventional or currently unrecoverable resources. For oil, oil sands represent tens of billions of barrels, heavy and conventional oil awaiting new technology—hundreds of billions of barrels, and oil shale—trillions of barrels of oil equivalent. For gas, ultradeep gas has hundreds of trillion cubic feet (TCF), tight gas sands—thousands of TCF (only 2% recoverable today), and the Holy Grail, natural gas hydrates—hundreds of thousands of TCF. How much of that will ever be technically recoverable, much less economically recoverable, remains to be seen.

Some barriers to exploiting these resources can readily be addressed with new policies and incentives; however significant technical challenges remain. Technology will be the driver that brings that hydrocarbon potential to its required fruition. And R&D will be the vehicle for that technology driver.

Who will conduct that R&D, and who will pay for it? Good questions; no easy answers.

EIA’s annual survey indicates upstream R&D expenditures by the majors fell to about $500 million by 2002. The majors have closed 6 R&D centers in the last few years as a result of the numerous mergers. The service industry has picked up a much larger share, about a billion dollars each year now, but is more focused on short-term, project-specific research.

Who will take advantage of future R&D needed to further exploit these mature domestic fields?

The answer to that question is: 5,000 domestic independents who drill nearly 90% of the wells, produce 80% of the gas and nearly 70% of the oil in the Lower 48 states, and have on average 12 employees. In general, an independent does not have enough resources to invest in R&D.

That's where DOE's oil and gas R&D programs have contributed. These programs principally target independent producers in America, so it follows that the emphasis is on reducing risk, lowering costs, and improving economic recovery of hydrocarbons.

As it has always been, the more one knows about the reservoir, the better able one is to economically produce the oil and gas in it and to increase ultimate recovery.

For the balance of my talk, I will discuss some advances in DOE R&D that can stimulate the use of and advance the science of seismic technology. These efforts will enable operators, particularly small independents, to use the products of seismic technology to characterize reservoir behavior to a cost-effective degree never seen before.

It is with this context in mind that I suggest the geophysical industry now faces a *"perfect storm"* of opportunity in the broader deployment of economic seismic methods for imaging subsurface features and characterizing reservoir behavior.

Many of you recall that the advent of 3-D seismic was also seen as such a panacea for the industry's exploration and exploitation challenges. While this most important technology innovation delivered tremendous value to the operator, the contractor's return on investment in 3-D seismic ultimately has proven disappointing. There is overcapacity and a lot of data. Similarly, the great benefits of multicomponent seismic aren't being realized to their fullest extent because of cost issues.

Although the technical feasibility and value of vertical seismic profiling has been demonstrated thoroughly over the years, Vertical Seismic Profile imaging has yet to cross the bridge from 2-D to 3-D. Operators now take high-quality 3-D images for granted, so 2-D VSP doesn't have the appeal it might have had otherwise. The barrier in the move to 3D VSP imaging is cost, not technology.

Yet the benefits are inarguable. Multicomponent VSP data is the most reliable way to underpin the rigor of correspondence between stratigraphic depth and P and S wave image times.

DOE's R&D emphasizes low-cost access and entry methods for deploying VSP. NETL's Microhole Initiative is one such enabling suite of technologies. The primary microhole program driver is a shallow resource not economically recoverable with current technology—218 billion barrels of oil at less than 5,000 feet in the U.S. Shallow gas targets represent another driver.

Marrying the concept of smaller, easily transportable coiled tubing rigs for drilling ultrasmall-diameter holes to the deployment of miniaturized downhole sensors could spur a revolutionary approach to U.S. oil and gas exploration. A key to advancing the microhole technology initiative is the development of economic, high-resolution seismic methods for subsurface imaging with microelectromechanical systems, or MEMS, technology. Such miniature sensors under development are demonstrating performance capabilities approaching those of conventional geophones.

DOE-funded research has successfully demonstrated the coiled tubing drilling of wells as small as 1¾ inches as deep as 800 feet, and we have field-tested MEMS sensors in microholes cased with 1¼-inch tubing.

The Microhole Initiative encompasses technologies to support business models for improving reservoir and prospect imaging via VSP deployed with MEMS technology and very low-cost instrumentation drilling. Microinstrumentation holes can cost from one tenth to one fourth that of conventional holes. Work undertaken at the Rocky Mountain Oil Field Testing Center suggests that such dedicated microbores could be drilled to 500 feet at a drilling cost of $15,000, or $26,000 for all-in completion costs. In addition, estimated drilling cost reductions of as much as 50% in development and injection wells could spawn a new wave of infill drilling in America's mature fields.

Dr. Ernie Majors of the Lawrence Berkeley National Laboratory has been investigating passive VSP for some time. He is leading the Vertical Seismic Profile imaging work at RMOTC, using VSP to look down into the reservoir. Initial tests last year demonstrated active VSP "sees" down four times (or more) of hole depth with up to three times better resolution than "conventional" VSP (better signal-to-noise). The surveys themselves are faster and cheaper. Further tests using more holes will be carried out this summer, so expect to see some reports coming from Dr. Majors on these results.

Embracing new technology—indeed, a new paradigm—such as microhole could mean the seismic industry shifting to a wholly new business model in order to thrive and prosper.

In addition to the Microhole Initiative, DOE R&D focuses on other technologies that promise to deliver greater clarity and understanding to imaging and characterizing the subsurface and downhole conditions.

My esteemed colleague, Dr. Bob Hardage, who presented this morning, discussed his participation in a DOE-funded supported project that demonstrated shear wave data could be used for imaging Morrow trend stratigraphy with nine-component VSP data. This strongly supports the premise that multicomponent seismic technology can be used for improved stratigraphic identification and reservoir characterization. And the breakthrough can be applied to other reservoirs where P-wave data are inadequate.

The success of a DOE-led project in the South Elwood heavy oil field offshore California cracked the complexity of the Monterey chert. By developing a new algorithm to interpret fault patterns from reprocessed seismic data, it was possible to more precisely locate well paths for redeveloping the field and to identify three new fault block targets with potential reserves estimated at 80 million barrels of oil.

We also have the Intellipipe project, which entailed developing a high-speed telemetry drill pipe capable of transmitting high-bandwidth downhole data as well as surface control signals. Intellipipe represents a dramatic advance in collecting high-resolution seismic data ahead of the drill bit. Capable of data transmission rates of up to 2 million bits per second, this technology already has tremendous commercial potential.

Although part of the Microhole Initiative, a DOE-funded project by Stolar Research has potential for application beyond that program.

This project promises to develop a radar-guided drilling system for horizontal wells. It is integrated with a coiled tubing bottomhole assembly and a two-way, inductive radio data transmission system along the coiled tubing for real-time measurement-while-drilling in microbores. (We believe that the radar can image about 200 feet.) Comparable diagnostic advances are on tap with the Deep Trek program, initiated by DOE in 2001. The driver for Deep Trek is a potential gas resource at 15,000-30,000 feet estimated at 133 TCF. Among other technologies, Deep Trek will focus on developing real-time data acquisition systems under downhole conditions that exceed 350 degrees F. and 10,000 psi. One project seeks to develop a real-time pore pressure detection system utilizing an improved seismic-while-drilling tool and incorporating automatic kick detection and control.

Paulsson Geophysical Services is a DOE partner in a couple of projects. One is to develop a 400-level, 3-component clamped downhole seismic receiver array and the other is to develop accompanying software for borehole 3-D seismic imaging. The combined goal is to remove technical acquisition barriers for recording the volumes of data needed to perform high-resolution 3-D VSP or 3-D crosswell seismic imaging. Paulsson's third-generation receiver pods and cables represent a major step forward in borehole seismic imaging. The plan is to complete five 80-level arrays that will result in the first-ever 400-level recording system. A commercially available 400-level, 3C borehole seismic receiver array will make it possible to economically map high-permeability zones and monitor production in heterogeneous and fractured reservoirs with a resolution up to 10 times over what is possible with existing technology. For example, where standard seismic could image down to a 40-foot sand lens, this new system can image down to a 4-foot feature in the same reservoir. We believe this translates into a 10-30 percent increase in enhanced recovery of oil and gas from complex reservoirs. And the receiver pods and cables are capable of operation at 400 degrees F and 25,000 psi.

Speaking of enhanced recovery, a project in the Hall-Gurney oil field in Kansas entails 4-D monitoring of a multi-year CO_2 flood. Utilizing a series of seven 3-D surveys to build a 4-D program, Dr. Rick Miller of the Kansas Geological Survey was able to determine that 84% of the changes in seismic properties were the result of CO_2 saturation. Changes in production schemes made possible by incorporating nearly real-time monitoring data into CO_2 injection EOR programs could dramatically improve the efficiency and economics of that technology in many Midcontinent fields. Refinements to 3-D high-resolution reflection-imaging approaches resulting from this study could make seismic data an improved tool for providing assurances essential for routine sequestration of CO_2 in depleted oil/gas reservoirs or brine aquifers.

Those are just a few examples of the new technologies emerging from DOE's oil and gas R&D program that are designed to bring the subsurface into the sharper focus that industry needs.

This technology need will become more critical than ever as America increasingly faces a choice: between continued reliance on its "greying" fields with their hundreds of billions of oil-equivalent barrels currently locked up—and total dependency on oil and gas imports.

To reiterate, technology will be the driver that enables the U.S. to capture more of its hydrocarbon potential, propelled by R&D. It will require a new approach by the seismic industry to capitalize on that R&D—and on the opportunity for its next growth stage, in an era marked by rising concerns over ever-tightening oil and gas supplies.

Thank you all for your kind attention and the honor of speaking to you today. I would be happy to take any questions you might have.